

LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER

LEVEL



INVENTORY

Interim rpt. for Bioventing Field.
DOCUMENT IDENTIFICATION
10 Nov 92

H
A
N
D
L
E

W
I
T
H

C
A
R
E

DISTRIBUTION STATEMENT A

Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSIONED	
NTIS	GRAM
DTIC	TRAC
UNANNOUNCED	
JUSTIFICATION	
BY	
DISTRIBUTION/	
AVAILABILITY CODES	
DISTRIBUTION	AVAILABILITY AND/OR SPECIAL
A-1	
DISTRIBUTION STAMP	

DATE ACCESSED

DATE RETURNED

REGISTERED OR CERTIFIED NUMBER

20001215 104

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

INTERIM REPORT
November 10, 1992

FOR

BIOVENTING FIELD INITIATIVE

AT

**SITE UST 173
ROBINS AIR FORCE BASE, GEORGIA**

to

**Captain Catherine M. Vogel
Department of the Air Force
Building 1117
HQ AFESC/RDVW
Tyndall AFB, Florida 32403-6001**

by

**BATTELLE
Columbus Operations
505 King Avenue
Columbus, Ohio 43201-2693**

AQM01-03-0555

**DEFENSE TECHNICAL INFORMATION CENTER
REQUEST FOR SCIENTIFIC AND TECHNICAL REPORTS**

Title

AFCEE Collection

1. Report Availability (Please check one box)

- This report is available. Complete sections 2a - 2f.
 This report is not available. Complete section 3.

2a. Number of Copies Forwarded

1 each

2b. Forwarding Date

July/2000

2c. Distribution Statement (Please check ONE box)

- DoD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly below. Technical documents MUST be assigned a distribution statement.*
- DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.
 DISTRIBUTION STATEMENT B: Distribution authorized to U.S. Government Agencies only.
 DISTRIBUTION STATEMENT C: Distribution authorized to U.S. Government Agencies and their contractors.
 DISTRIBUTION STATEMENT D: Distribution authorized to U.S. Department of Defense (DoD) and U.S. DoD contractors only.
 DISTRIBUTION STATEMENT E: Distribution authorized to U.S. Department of Defense (DoD) components only.
 DISTRIBUTION STATEMENT F: Further dissemination only as directed by the controlling DoD office indicated below or by higher authority.
 DISTRIBUTION STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, 6 Nov 84.

2d. Reason For the Above Distribution Statement (in accordance with DoD Directive 5230.24)

2e. Controlling Office

HQ AFCEC

2f. Date of Distribution Statement Determination

15 Nov 2000

3. This report is NOT forwarded for the following reasons. (Please check appropriate box)

- It was previously forwarded to DTIC on _____ (date) and the AD number is _____
 It will be published at a later date. Enter approximate date if known.
 In accordance with the provisions of DoD Directive 3200.12, the requested document is not supplied because:

Print or Type Name

Laura Peña
Telephone
210-536-1431

Signature

Laura Peña
For DTIC Use Only
AQ Number M01-03-0555

TABLE OF CONTENTS

1.0 INTRODUCTION	1
1.1 Objectives	1
1.2 Site Description	2
2.0 CHRONOLOGY OF EVENTS AND SITE ACTIVITIES	2
2.1 Soil Gas Survey	2
2.2 Vent Well and Monitoring Point Installation	4
2.3 Soil and Soil Gas Sampling and Analyses	8
2.4 Soil Gas Permeability and Radius of Influence	8
2.5 In Situ Respiration Test	8
3.0 RESULTS AND DISCUSSION	11
3.1 Soil and Soil Gas Analyses	11
3.2 Soil Gas Permeability and Radius of Influence	11
3.3 In Situ Respiration Test	11
3.4 Bioventing Demonstration	17
4.0 BACKGROUND AREA	17
5.0 FUTURE WORK	17
6.0 REFERENCE	20
APPENDIX A: ANALYTICAL REPORT FOR SITE UST 173	A-1
APPENDIX B: SITE UST 173 SOIL GAS PERMEABILITY DATA	B-1
APPENDIX C: SITE UST 173 IN SITU RESPIRATION TEST DATA	C-1

LIST OF TABLES

Table 1. Initial Soil Gas Composition at Site UST 173	5
Table 2. Results From Soil and Soil Gas Analyses for BTEX and TPH at Site UST 173	12
Table 3. Results From Soil Chemistry Analyses at Site UST 173	13
Table 4. Results of Hyperventilate™ Soil Gas Permeability Analysis	13
Table 5. Oxygen Utilization and Carbon Dioxide Production Rates During In Situ Respiration Test at Site UST 173	16

LIST OF FIGURES

Figure 1. Schematic Diagram of Site UST 173 at Robins AFB	3
Figure 2. Cross-Section of Vent Well and Monitoring Points Location at Site UST 173	6
Figure 3. Schematic Diagram of the Vent Well Construction at Site UST 173	7

Figure 4. Schematic Diagram of a Typical Monitoring Point Construction at Site UST 173	9
Figure 5. Calculation of Radius of Influence at Site UST 173	14
Figure 6. Oxygen Utilization During In Situ Respiration Test at Monitoring Point R1-MPA- 14'3"	15
Figure 7. Schematic Diagram of Vent Well Construction at the Background Area	18
Figure 8. Oxygen Utilization During In Situ Respiration Test at Background Area	19

INTERIM REPORT
BIOVENTING FIELD INITIATIVE
AT
SITE UST 173
ROBINS AIR FORCE BASE, GEORGIA

1.0 INTRODUCTION

This report describes the activities conducted at Robins Air Force Base (AFB), Georgia, Site UST 173 as part of the Bioventing Field Initiative for the U.S. Air Force Center for Environmental Excellence (AFCEE). This report summarizes the results from the first phase of the study at Robins AFB which includes a soil gas survey, air permeability test, in situ respiration tests, and installation of bioventing systems. The specific objectives of this task are described in the following section.

1.1 Objectives

The purpose of these field test methods is to measure the soil gas permeability and microbial activity at a contaminated site and to evaluate the potential application of the bioventing technology to remediate the site. The specific test objectives are stated below.

- A small-scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. Soil gas from the candidate site should exhibit relatively high total petroleum hydrocarbon (TPH) concentrations, relatively low oxygen concentrations, and relatively high carbon dioxide concentrations. An uncontaminated background location will also be identified.
- The soil gas permeability of the soil and the air vent (well) radius of influence will be determined. This will require air to be withdrawn or injected for approximately 8 hours at vent wells located in contaminated soils. Pressure changes will be monitored in an array of monitoring points.
- Immediately following the soil gas permeability test, an in situ respiration test will be conducted. Air will be injected into selected monitoring points to aerate the soils. The in situ oxygen utilization and carbon dioxide production rates will be measured.
- Using the data from the soil gas permeability and in situ respiration tests, an air injection/withdrawal rate will be determined for use in the bioventing test. A blower will be selected, installed, and operated for 6 to 12 months, and periodic measurements of the soil gas composition will be made to evaluate the long-term effectiveness of bioventing.

1.2 Site Description

Robins AFB is located approximately 10 miles south of Macon, Georgia, adjacent to the town of Warner Robins, Georgia. Site UST 173 had a 1,500-gallon diesel tank next to Building 173 on the base that was abandoned in place approximately 20 years ago. The tank was removed in October 1989. Site investigation activities conducted subsequent to the tank removal indicated residual soil contamination. The site was re-excavated, and approximately 200 cubic yards of soil were removed for disposal. Soil contamination remained on the southern boundaries of the excavation, but could not be removed without undermining the foundation of a gazebo on site. Soil samples taken from the south wall of the excavation pit exhibited TPH concentrations as high as 22,600 ppm. Elevated concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) also were detected. Figure 1 is a schematic diagram of Site UST 173. Soil borings taken at the site during the site investigation show dense, clayey sand to a depth of approximately 5 feet; coarse sand and gravel to approximately 25 feet; and stiff, tannish white clay below 25 feet. All borings were terminated in the stiff clay, and no groundwater was encountered.

2.0 CHRONOLOGY OF EVENTS AND SITE ACTIVITIES

2.1 Soil Gas Survey

A site deemed suitable for the bioventing demonstration should have soil gas characteristics of low oxygen, high carbon dioxide, and high TPH. This composition of soil gas would indicate that oxygen-limiting conditions for microbial activity are present and that the introduction of air may enhance biodegradation of TPH.

A limited soil gas survey was conducted to locate a suitable test area at Site UST 173 on August 25, 1992. Soil gases were sampled by driving a $\frac{5}{8}$ -inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH.

Measurements of oxygen and carbon dioxide in the soil gas were made with a GasTech Model 32530X with oxygen and carbon dioxide ranges of 0 to 25%. The analyzer was calibrated daily against atmospheric oxygen, atmospheric carbon dioxide, a 10% oxygen calibration standard, and a

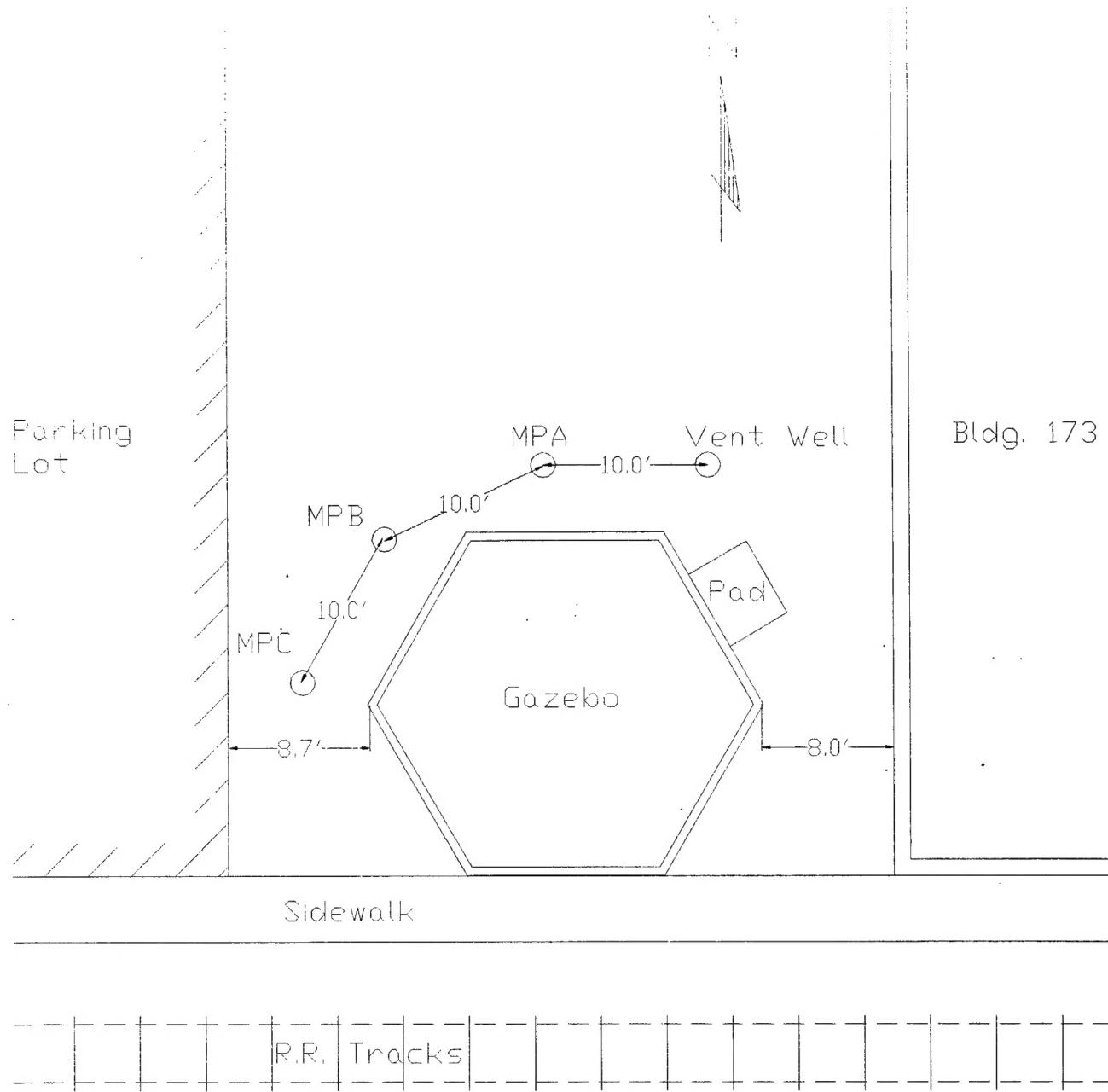


Figure 1. Schematic Diagram of Site UST 173 at Robins AFB

5% carbon dioxide calibration standard. TPH was measured with a GasTech Trace Techtor with TPH ranges from 0 to 100, 0 to 1,000, and 0 to 10,000 ppm. The GasTech Trace Techtor was calibrated daily against a 4,200 ppm hexane standard.

The soil gas probes were driven to depths ranging from 2.5 to 10.0 feet at several locations at Site UST 173. Table 1 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Site UST 173. Oxygen concentrations varied from 0 to 19.2%, whereas TPH concentrations ranged from 0 to greater than 20,000 ppm. These results indicate that, although not all areas of the site are oxygen-limited, some areas may respond to bioventing.

2.2 Vent Well and Monitoring Point Installation

On August 26, 1992, the vent well (VW) and three monitoring points were installed, and collection of soil samples for analyses was begun. The monitoring points were labelled R1-MPA, R1-MPB, and R1-MPC. The locations of the vent well and monitoring points are shown in Figure 1. A cross-section of the vent well and monitoring points is shown in Figure 2.

The vent well was installed at a depth of 23.3 feet into a 6-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter polyvinyl chloride (PVC) piping with 10 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand; the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface. A schematic diagram of the vent well construction is shown in Figure 3.

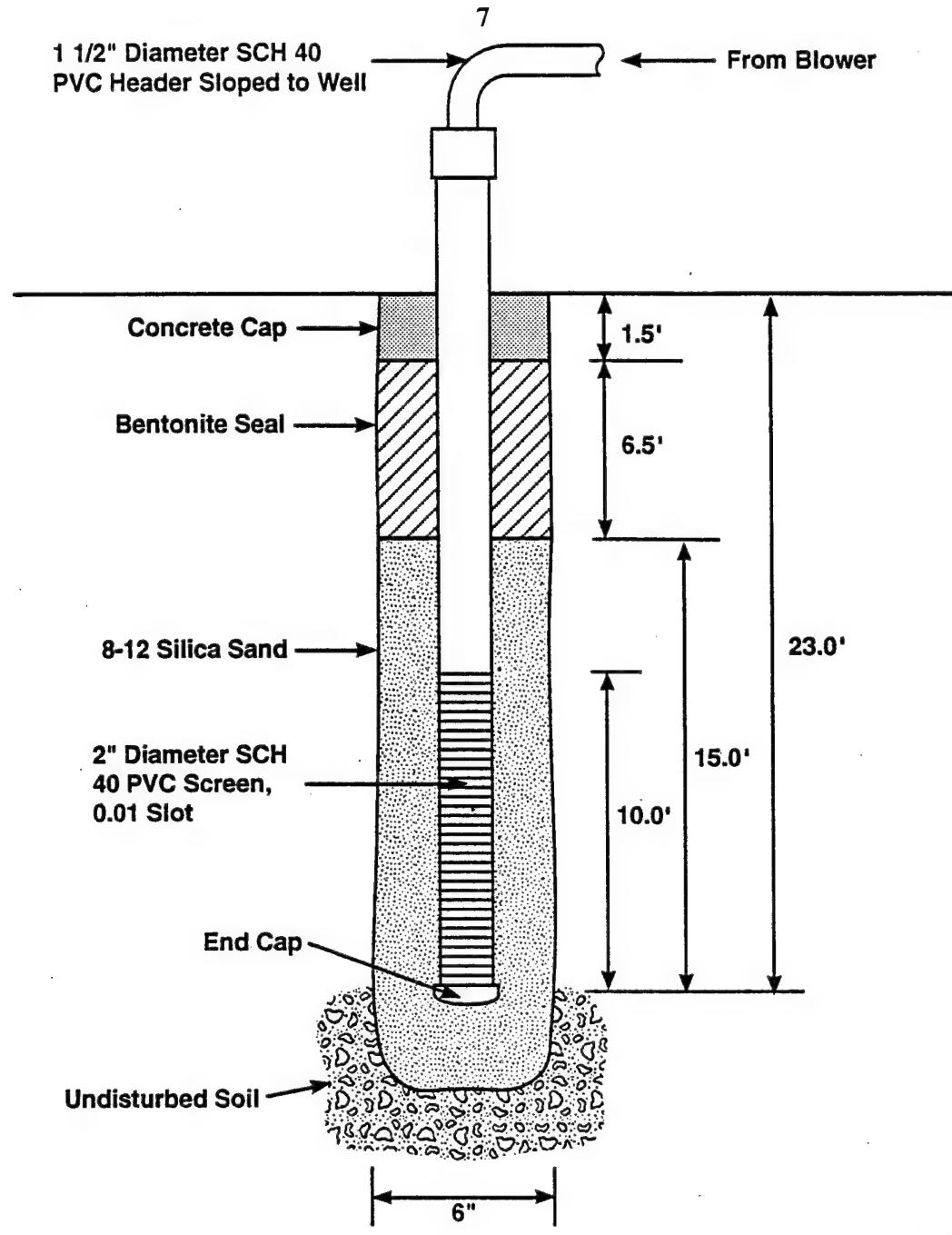
Soil gas probes consisted of ¼-inch tubing with a 6-inch screened area ½-inch in diameter. The annular space corresponding to the screened area was filled with silica sand. The interval between the screened areas was filled with bentonite, as was the annular space from the shallowest monitoring point to the ground surface. The monitoring points were installed at depths as follows:

- Monitoring point R1-MPA was installed at a depth of 22'4" into a 6-inch-diameter borehole. The monitoring point was screened to three depths: 21'10", 14'3", and 6'10".
- Monitoring point R1-MPB was installed at a depth of 23'6" into a 6-inch-diameter borehole. The monitoring point was screened to three depths: 23', 15', and 8'.
- Monitoring point R1-MPC was installed at a depth of 23'6" into a 6-inch-diameter borehole. The monitoring point was screened to three depths: 23', 15', and 8'.

Table 1. Initial Soil Gas Composition at Site UST 173

Soil Gas Survey (GS) Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	15	4.5	145
	5	11.7	6.5	360
	7.5	17.2	3.0	160
	10	11	8.0	620
GS-2	2.5	11	7.7	380
	5	19.2	1.5	240
	7.5	0	9.2	>20,000
GS-3	2.5	9.5	7.2	380
	5	19	1.5	88
	7.5	12	5.6	230
	10	14	5.5	280
GS-4	2.5	12.3	5.8	360
	5	15.8	2.3	>10,000
	7.5	18	1	1,200
	10	11.5	7.5	380
GS-6	2.5	8.5	9.5	100
	5	15	4.2	84
GS-8	2.5	13.8	2.5	100
	5	17.5	4.1	0

Figure 2. Cross-Section of Vent Well and Monitoring Points Location at Site UST 173



F/Kittel/11-05

Figure 3. Schematic Diagram of the Vent Well Construction at Site UST 173

A schematic diagram of the construction detail of a typical monitoring point for this site is shown in Figure 4.

2.3 Soil and Soil Gas Sampling and Analyses

Soil boring samples were collected at depths of 4.0, 18.0, and 18.5 feet from the Site UST 173 vent well borehole and were labelled R1-V-4.0'-4.5', R1-V-18.0', and R1-V-18.5'-19.0'. The samples were sent under chain of custody to Engineering-Science Berkeley Laboratory for analysis of BTEX, TPH, iron, and soil chemistry. A soil sample was also taken from monitoring point R1-MPA at a depth of 8.5 feet and labelled R1-MPA-8.5'-10.0'. Soil gas samples also were collected from the vent well and from monitoring points R1-MPA and R1-MPC, and a sample of ambient air was taken. These samples were labelled R1-VW, R1-MPA-21'10", R1-MPC-15', and ambient. These samples were sent under chain of custody to Air Toxics, Ltd. in Rancho Cordova, California, for analysis of BTEX and TPH.

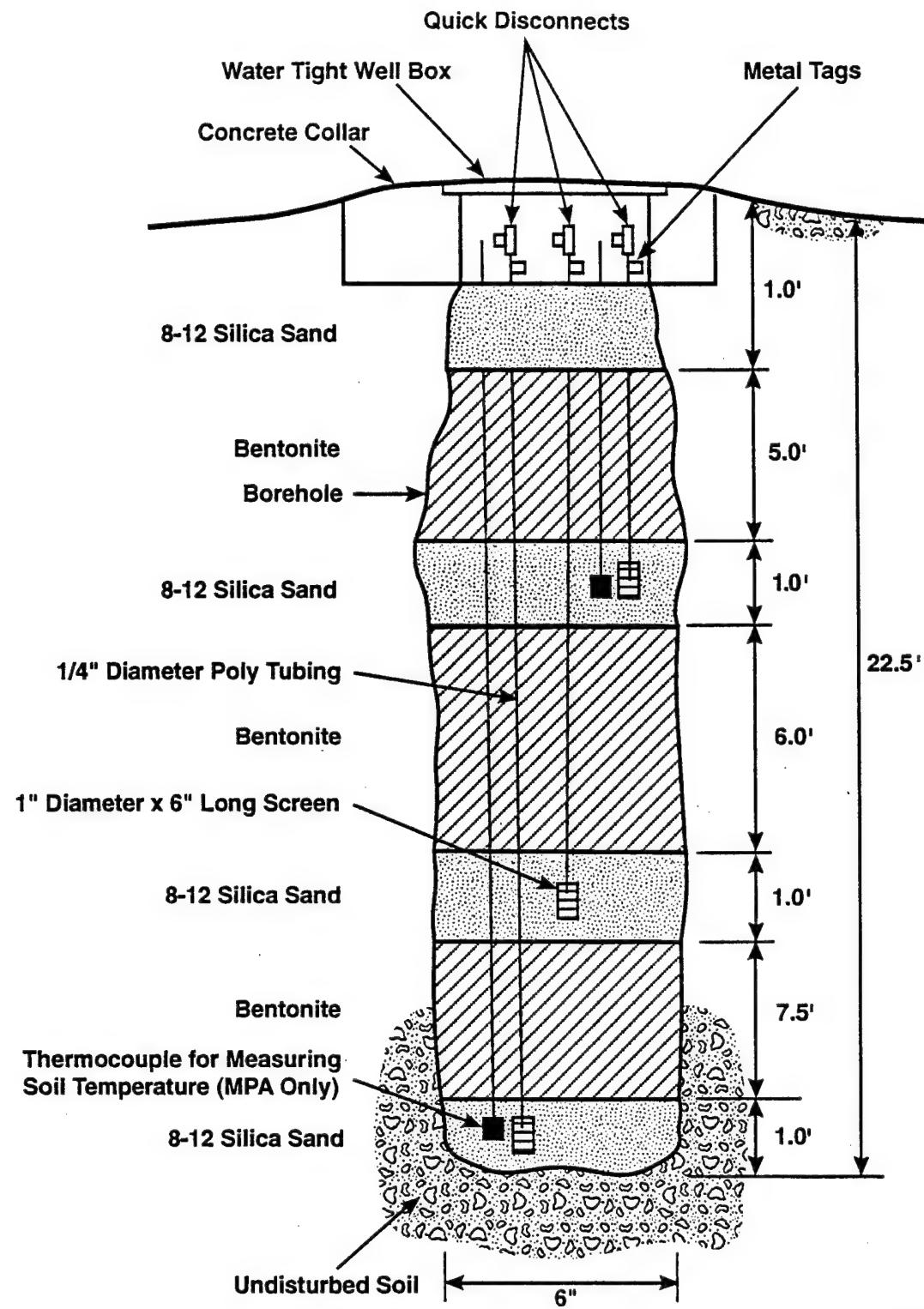
2.4 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k , the soil gas permeability, is presented in "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing" (Hinchee et al., 1992).

The monitoring points at Site UST 173 were allowed to set in place for 24 hours prior to air injection. A portable 1-horsepower (HP) explosion-proof positive displacement blower unit was used to inject air. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The Hyperventilate™ computer model was used to calculate the soil gas permeability.

2.5 In Situ Respiration Test

Immediately following the soil gas permeability test at Site UST 173, air containing approximately 1% helium was injected into the soil for approximately 24 hours beginning on September 1. Air was injected concurrently into the background monitoring well to measure the



F/KiteW/11-01

Figure 4. Schematic Diagram of a Typical Monitoring Point Construction at Site UST 173

natural biodegradation of organic material in the soil. The setup for the in situ respiration test was as described in "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing" (Hinchee et al., 1992). The pump used for air injection was a 1/2-HP diaphragm pump. Air and helium were injected through monitoring points R1-MPA-14'3", R1-MPA-21'10", R1-MPC-15', and R1-MPC-23' at the depths indicated by the labels. After the air/helium injection was turned off, the respiration gases were monitored periodically. The respiration test was terminated on September 8.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses about 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. This ratio can then be used as a comparison when monitoring diffusion of oxygen based on helium loss.

To compare data from one site to another, a stoichiometric relationship of the oxidation of the hydrocarbon was assumed. Hexane was used as the representative hydrocarbon for the organic contaminant. The stoichiometric relationship is given by:



Based on the utilization rates (% per day), the biodegradation rates in terms of mg as hexane equivalent per kg of soil per day were computed using the equation below by assuming a soil porosity of 0.2 and a bulk density of 1,440 kg/m³.

$$K_b = -\frac{K_o A D_o C}{100} \quad (2)$$

where: K_b = biodegradation rate (mg/kg/day)
 K_o = oxygen utilization rate (percent per day)
 A = volume of air/kg of soil, in this case 300/1,440 = 0.21
 D_o = density of oxygen gas (mg/L) assumed to be 1,330 mg/L
 C = mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1:3.5 from the above stoichiometric equation.

3.0 RESULTS AND DISCUSSION

3.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH are presented in Table 2. Relatively low concentrations of the BTEX compounds were found in soil samples, with concentrations ranging from below the detection limit to 3.0 mg/kg. TPH concentrations were high in sample R1-MPA-8.5'-10.0', while the other soil samples contained relatively low TPH concentrations. The soil gas analyses also showed relatively low BTEX and TPH concentrations with concentrations ranging from less than the detection limit up to 2.2 ppm of BTEX and from 27 to 300 ppm of TPH (Table 2). The results from the soil chemistry analyses are summarized in Table 3. The laboratory report for the BTEX, TPH, and the soil chemistry analysis is given in Appendix A.

3.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at Site UST 173 are presented in Appendix B. Using the Hyperventilate™ computer model, soil gas permeabilities were calculated at each of the monitoring points. These data are presented in Table 4. The soil gas permeability varied considerably between points with values ranging from 0.05 up to 10,200 darcy. The radius of influence for the vent well was calculated by plotting the log of the pressure at a specific monitoring versus the distance from the vent well (Figure 5). The radius of influence at Site UST 173 is estimated to be approximately 28 feet.

3.3 In Situ Respiration Test

The results of the in situ respiration test for Site UST 173 are presented in Appendix C. Each figure in Appendix C illustrates the oxygen, carbon dioxide, and helium concentrations as a function of time. An example of typical oxygen utilization and carbon dioxide production at this site is shown in Figure 6, which shows oxygen, carbon dioxide, and helium at monitoring point R1-MPA-14'3". Oxygen utilization and carbon dioxide production rates were relatively low at this site at all monitoring points. The oxygen utilization and carbon dioxide production rates and corresponding biodegradation rates are summarized in Table 5. The biodegradation rates measured at this site were

Table 2. Results From Soil and Soil Gas Analyses for BTEX and TPH at Site UST 173

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Total Xylenes (mg/kg)	Ethyl Benzene (mg/kg)	TPH¹ (mg/kg)
Soil	R1-V-4.0'-4.5'	< 0.29	< 0.33	3.0	0.33	37
	R1-V-18.5'-19.0'	< 0.0007	< 0.0008	0.0037	< 0.0006	8.0
	R1-MPA-8.5'-10.0'	< 0.0007	0.002	0.079	0.009	5,700
Matrix	Sample Name	Benzene (ppm)	Toluene (ppm)	Total Xylenes (ppm)	Ethyl Benzene (ppm)	TPH¹ (ppm)
Soil Gas	R1-VW	< 0.004	0.025	2.2	0.31	300
	R1-MPA-21'10"	< 0.002	0.052	0.81	0.055	290
	R1-MPC-15'	< 0.002	0.006	0.098	0.14	27
	Ambient Air ²	< 0.002	< 0.002	< 0.002	< 0.002	0.20

¹ TPH referenced to gasoline (Molecular Weight = 100)² Sample taken at R1-MPA.

Table 3. Results From Soil Chemistry Analyses at Site UST 173

Parameter	Sample Name		
	R1-V-4.0'-4.5'	R1-V-18'	R1-MPA-8.5'-10.0'
Alkalinity (mg/kg CaCO ₃)	< 50	< 50	< 50
Moisture (% by weight)	16.2	9.1	17.5
pH	4.9	5.4	5.2
Iron (mg/kg)	11,300	4,720	1,980
Total Phosphorous (mg/kg)	110	64	79
Total Kjeldahl Nitrogen (mg/kg)	110	92	68
Particle Size Analysis	Gravel: 0%	Gravel: 3%	Gravel: 0%
	Sand: 49%	Sand: 40%	Sand: 59%
	Silt: 20%	Silt: 37%	Silt: 22%
	Clay: 31%	Clay: 20%	Clay: 19%

Table 4. Results of Hyperventilate™ Soil Gas Permeability Analysis

Monitoring Point	Depth	Soil Gas Permeability (darcy)
R1-MPA	6'10"	0.050
	14'3"	570
	21'10"	10,200
R1-MPB	8'	180
	15'	320
	23'	140
R1-MPC	8'	44
	15'	0.17
	23'	770

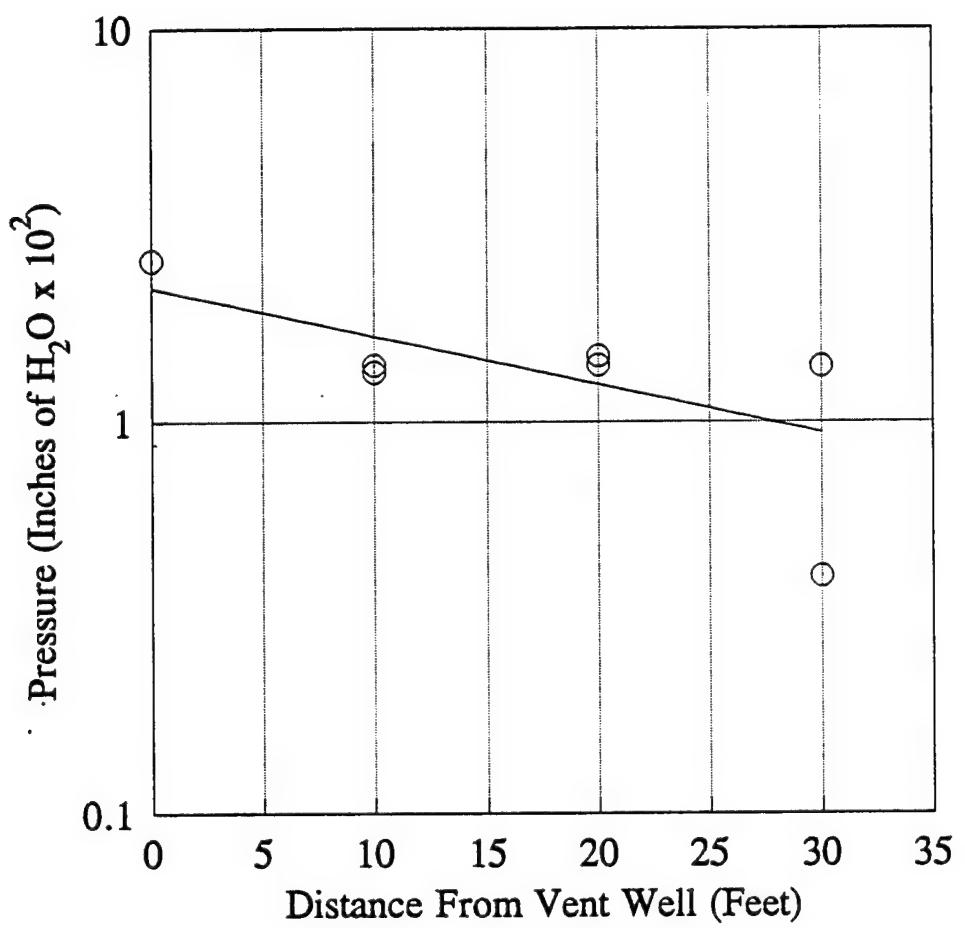


Figure 5. Calculation of Radius of Influence at Site UST 173

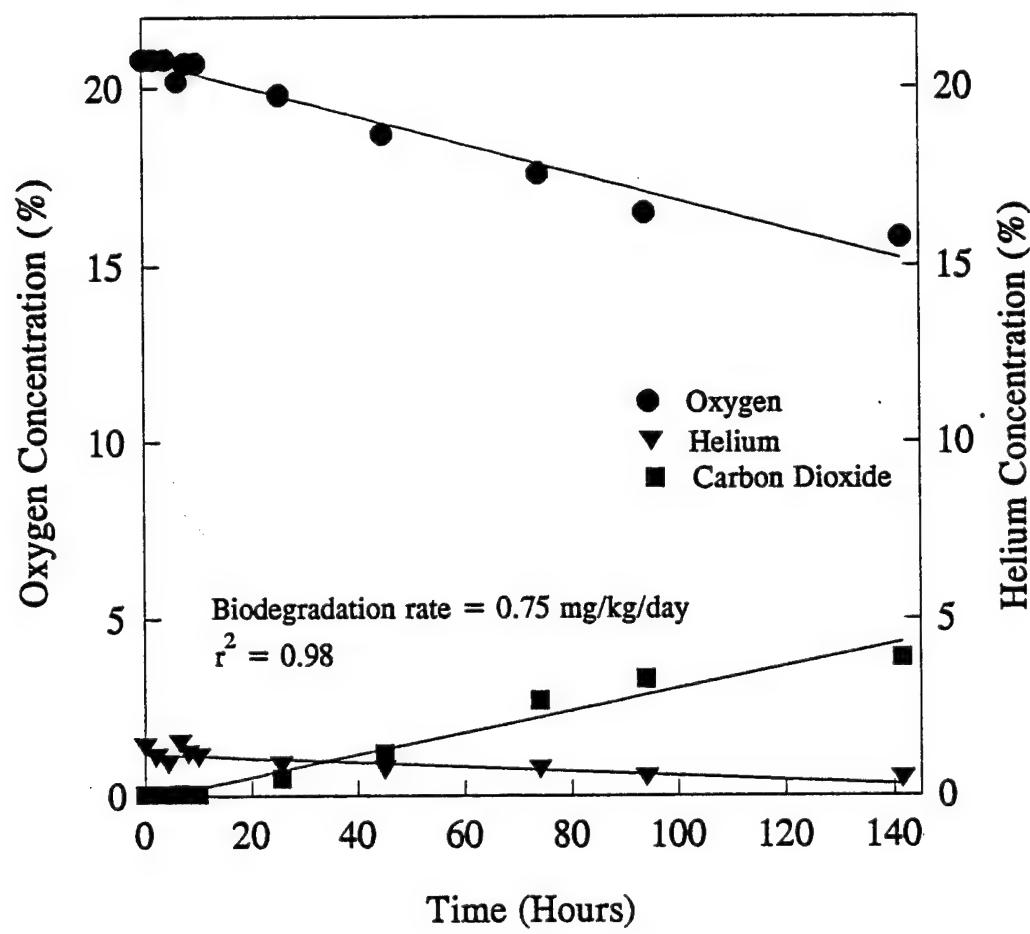


Figure 6. Oxygen Utilization During In Situ Respiration Test at Monitoring Point R1-MPA-14'3"

Table 5. Oxygen Utilization and Carbon Dioxide Production Rates During In Situ Respiration Test at Site UST 173

Sample Name	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0	0	0	0
R1-MPA-14'3"	0.039	0.75	0.015	0.31
R1-MPA-21'10"	0.028	0.54	0.031	0.68
R1-MPC-15'	0.029	0.56	0.024	0.51
R1-MPC-23'	0.020	0.38	0.015	0.31

fairly consistent between the monitoring points, with rates ranging from 0.38 to 0.75 mg/kg/day based upon oxygen and from 0.31 to 0.68 mg/kg/day for carbon dioxide, with a fairly good correlation between the oxygen utilization and carbon dioxide production rates.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well-sealed and that the oxygen depletion observed was a result of biodegradation.

3.4 Bioventing Demonstration

The decision was made to install a bioventing system at Site UST 173. The same blower that was used for the soil gas permeability test was installed for the bioventing system. Continuous air injection was initiated on September 4th at a flow rate of 12 cubic feet per minute (cfm).

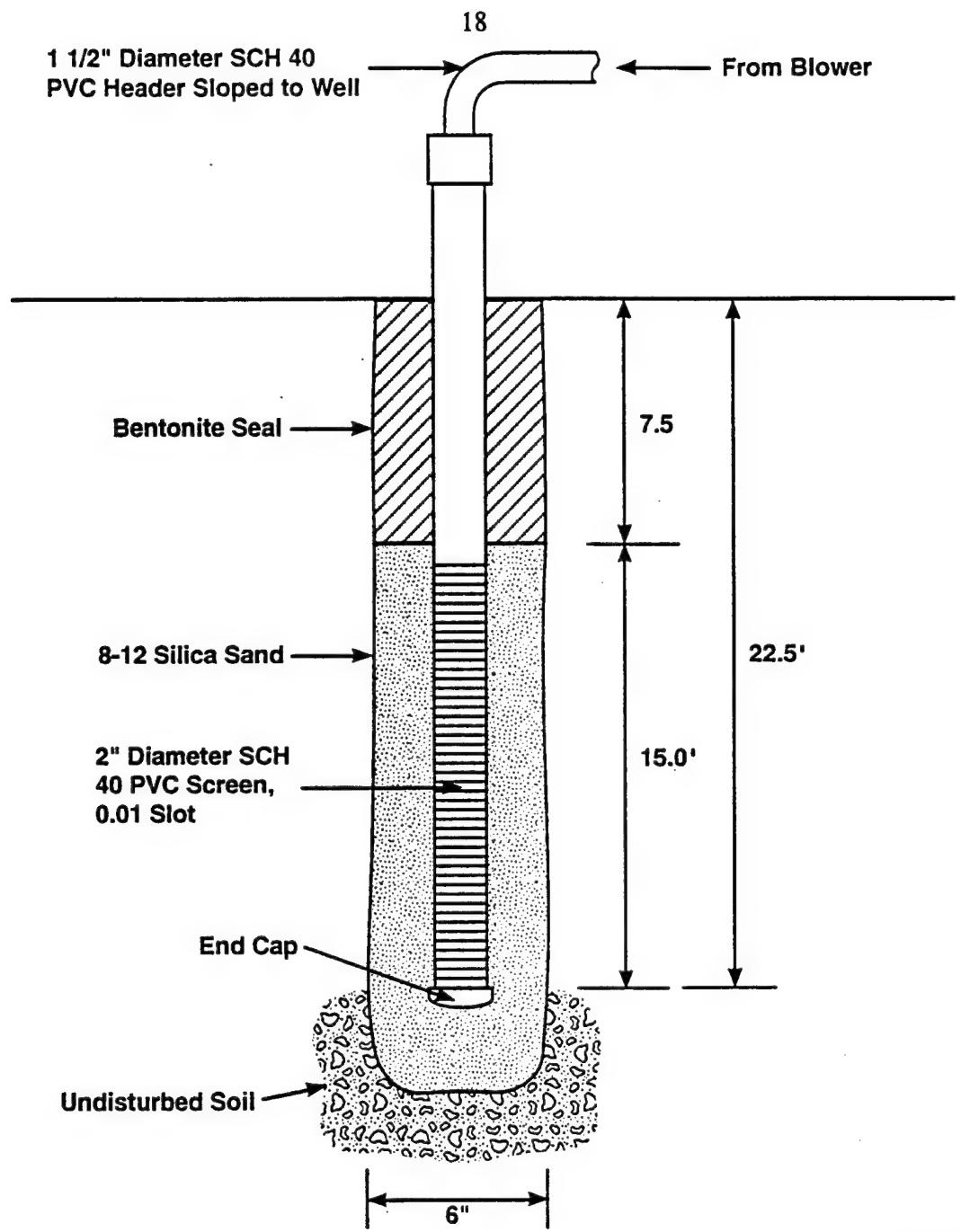
4.0 BACKGROUND AREA

A background vent well was installed on August 31, 1992. The depth of this vent well was 23 feet. Ten feet were screened using Schedule 40, 2-inch-diameter, 10 slot PVC, and the remaining 13 feet consisted of Schedule 40, 2-inch-diameter PVC riser. The first 15 feet of the vent well was surrounded by sand, while 6 of the remaining 8 feet was enclosed by bentonite to seal the vent well. A schematic diagram of the vent well construction is shown in Figure 7.

An in situ respiration test was conducted at the background area beginning on September 5 after 24 hours of air injection. The test was concluded on September 9. No significant biodegradation was detected in this area as shown in Figure 8.

5.0 FUTURE WORK

Base personnel will be required to perform a simple weekly system check to ensure that the blower is operating within its intended flow rate, pressure, and temperature range. This check must be coordinated with the base Point-of-Contact (POC). An on-site briefing for base personnel who will be responsible for blower system checks was conducted. The principle of operation was explained, and a simple checklist and logbook were provided for blower data. Base personnel will perform



F/Kltha/11-03

Figure 7. Schematic Diagram of Vent Well Construction at the Background Area

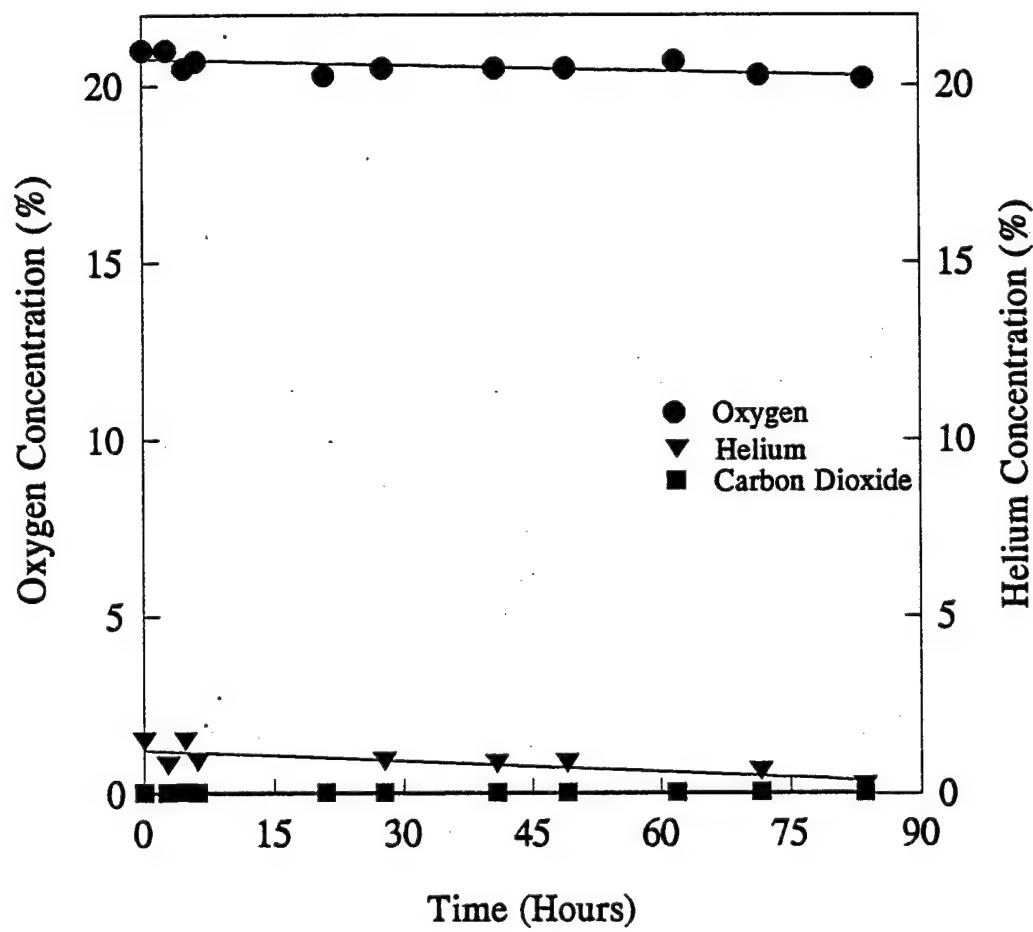


Figure 8. Oxygen Utilization During In Situ Respiration Test at Background Area

minor maintenance activities, such as replacing filters or gauges, or draining condensate from knockout chambers, but they will not be expected to perform complicated repairs or analyze gas samples. Replacement filters and gauges will be provided and shipped to the base by the contractor. Serious problems such as motor or blower failures will be corrected by the contractor.

The progress of this system will be monitored by conducting semiannual respiration tests in the vent well and in each monitoring point, and by regularly measuring the oxygen, carbon dioxide, and hydrocarbon concentrations in the extracted soil gas and comparing them to background levels. Soil gas monitoring will be performed on a quarterly basis. Semiannual respiration tests will be performed. At least twice each year, the progress of the bioventing test will be reported to the base POC.

6.0 REFERENCE

Hinchee, R.E., S.K.Ong, R.N.Miller, D.C.Downey, and R.Frandt. 1992. "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing," Revision 2.

APPENDIX A

ANALYTICAL REPORT FOR SITE UST 173

RESEARCH AND DEVELOPMENT
LABORATORY
600 BANCROFT WAY
BERKELEY, CALIFORNIA 94710
(415) 841-7353

ENGINEERING-SCIENCE, INC.

Report Date: October 9, 1992

Work Order No.: 4294

Client: Jeff Kittel
Battelle
505 King Ave.
Columbus, OH 43201

Date of Sample Receipt: 09/01/92

Your soil samples identified as:

R1-A-8.5'-10
R1-V-4.0'-4.5'

were analyzed for BTEX by EPA Method 8020, pH, alkalinity, iron, total Kjeldahl nitrogen, moisture, TRPH by EPA Method 418.1, soil classification by ASTM D422 and total phosphorus.

In addition your soil sample identified as:

R1-V-18'

was analyzed for pH, alkalinity, iron, total Kjeldahl nitrogen, moisture soil classification by ASTM D422 and total phosphorus.

Finally your soil sample identified as:

R1-V-18.5-19'

was analyzed for BTEX by EPA Method 8020 and TRPH by EPA Method 418.1.

The analytical reports for the samples listed above are attached.

LEGEND FOR INORGANIC RESULT QUALIFIERS

- U The analyte was analyzed for but not detected.
- B Reported value is less than Reporting limit but greater than the IDL.
- N Spiked sample recovery not within control limits.
- S Reported value was determined by the Method of Standard Additions.
- * Duplicate analysis not within control limits.
- W Post digestion spike for Furanc AA analysis out of control limits (85-115%), while sample absorbane is less than 50% of spike absorbance
- + Correlation co-efficient for MSA is less than 0.995.
- E The reported value is estimated because of the presence of interference.
- R Quality Control indicates that data are not usable (compound may or may not be present). Re-sampling and re-analysis is necessary for verification.
- M Duplicate injection precision not met.

07/92

GC VOLATILES DATA PACKAGE

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: 17.5

Client ID: R1-A-8.5'-10'

Matrix: SOIL

Laboratory ID: 4294-1

Level: LOW

Unit: ug/KG

Dilution Factor: 1

Date Analyzed: 09/04/92

Date Confirmed: 09/08/92

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.7
Ethyl Benzene	6.3	9.0	0.6
Toluene	2.7	2.0	0.8
Xylenes (total)	89.6	79.0	1.1

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AD

GROUP LEADER: *fusel*

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: 16.2

Client ID: R1-V-4.0'-4.5'

Matrix: SOIL

Laboratory ID: 4294-2

Level: MEDIUM

Unit: ug/KG

Dilution Factor: 4

Date Analyzed: 09/08/92

Date Confirmed: 09/09/92

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	290.0
Ethyl Benzene	330.0	330.0	240.0
Toluene	ND	ND	330.0
Xylenes (total)	1200	3000.0	430.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AM

GROUP LEADER:

John

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: 14.9

Client ID: R1-V-18.5'-19'

Matrix: SOIL

Laboratory ID: 4294-4

Level: LOW

Unit: ug/KG

Dilution Factor: 1

Date Analyzed: 09/08/92
Date Confirmed: 09/04/92

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.7
Ethyl Benzene	ND	ND	0.6
Toluene	ND	ND	0.8
Xylenes (total)	1.1	3.7	1.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: *AB*GROUP LEADER: *Frank*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: NA

Client ID: METHOD BLANK

Matrix: SOIL

Laboratory ID: MSVG5920904

Level: LOW

Unit: ug/KG

Dilution Factor: 1

Date Analyzed: 09/04/92
Date Confirmed:

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.6
Ethyl Benzene	ND	ND	0.5
Toluene	ND	ND	0.7
Xylenes (total)	ND	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: M2

GROUP LEADER: *huron*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: NA

Client ID: METHOD BLANK

Matrix: SOIL

Laboratory ID: MWVG5920909

Level: MEDIUM

Unit: ug/KG

Dilution Factor: 1

Date Analyzed: 09/09/92
Date Confirmed: NA

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	60.0
Ethyl Benzene	ND	ND	50.0
Toluene	ND	ND	70.0
Xylenes (total)	ND	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER:

Revert

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: NA

Client ID: METHOD BLANK

Matrix: SOIL

Laboratory ID: MSVG3920908B

Level: LOW

Unit: ug/KG

Dilution Factor: 1

Date Analyzed: 09/08/92

Date Confirmed:

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.6
Ethyl Benzene	ND	ND	0.5
Toluene	ND	ND	0.7
Xylenes (total)	ND	ND	0.9

ND-Not Detected

NA-Not Applicable

D-Dilution Factor

ANALYST: *Am*GROUP LEADER: *Lund*

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: NA

Client ID: METHOD BLANK

Matrix: SOIL

Laboratory ID: MWVG3920908B

Level: MEDIUM

Unit: ug/KG

Dilution Factor: 1

Date Analyzed: 09/08/92
Date Confirmed: NA

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	60.0
Ethyl Benzene	ND	ND	50.0
Toluene	ND	ND	70.0
Xylenes (total)	ND	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER:

Russell

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED : 09/08/92
LAB SAMPLE ID: MWVG3920908B DATE EXTRACTED : NA
MATRIX : MEDIUM SOIL INSTRUMENT ID: VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
----- MWVG3920908B 4294-2	----- METHOD BLANK R1-V-4.0-4.5'	----- 09/08/92 09/08/92

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED : 09/09/92
LAB SAMPLE ID: MWVG5920909 DATE EXTRACTED : NA
MATRIX : MEDIUM SOIL INSTRUMENT ID: VGC-5

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
----- MWVG5920909 4294-2	----- METHOD BLANK R1-V-4.0-4.5	----- 09/09/92 09/09/92

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED : 09/04/92
LAB SAMPLE ID:MSVG5920904 DATE EXTRACTED : NA
MATRIX : SOIL INSTRUMENT ID:VGC-5

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG5920904	METHOD BLANK	09/04/92
SSVG5920904A	SPIKE	09/04/92
SSVG5920904B	SPIKE DUP	09/04/92
4294-1	R1-A-8.5'-10'	09/04/92
4294-4	R1-V-18.5'-19'	09/04/92

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED : 09/08/92
LAB SAMPLE ID:MSVG3920908B DATE EXTRACTED : NA
MATRIX : SOIL INSTRUMENT ID: VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
-----	-----	-----
MSVG3920908B	METHOD BLANK	09/08/92
4294-1	R1-A-8.5'-10'	09/08/92
4292-4	R1-V-18.5'-19'	09/08/92

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: MEDIUM SOIL

COLUMN ID: VGC-5 DB624

DATE: 09/09/92

=====

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

=====

MWVG5920909
4294-2

METHOD BLANK
R1-V-4.0'-4.5'

97
62

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: MEDIUM SOIL

COLUMN ID: VGC-3 VOCOL

DATE: 09/08/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MWVG3920908B
4294-2

METHOD BLANK
R1-V-4.0'-4.5'

118
52

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

COLUMN ID: VGC-3 VOCOL

DATE: 09/08/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MSVG3920908B
4294-1
4294-4

METHOD BLANK
R1-A-8.5'-10'
R1-V-18.5'-19'

110
77
97

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

COLUMN ID: VGC-5 DB624 DATE: 09/04/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MSVG5920904	METHOD BLANK	99
SSVG5920904A	SPIKE	105
SSVG5920904B	SPIKE DUP	101
4294-1	R1-A-8.5'-10'	73
4294-4	R1-V-18.5'-19'	88

**TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
DATA PACKAGE**

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

=====

ORGANIC ANALYTICAL REPORT

Work Order NO.: 4294

Matrix: Soil

Parameter: TPH

Unit: mg/Kg

Analytical

Method: 418.1

Date Extracted: 09/15/92

QC Batch NO.: S92QCB023TPH

Date Analyzed: 09/22/92

=====

Sample ID:	Client ID:	Result	Reporting Limit	Percent Moisture
4294-01	R1-A-8.5'-10'	5700	5	17.5
4294-02	R1-V-4.0'-4.5'	37	5	16.2
4294-04	R1-V-18.5'-19'	8	5	14.9
MSTPH920915	METHOD BLANK	ND	4	NA

=====

NA_ Not Analyzed
ND_ Not Detected

ANALYST:

Stan J

GROUP LEADER:

Levi

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

ORGANIC QUALITY CONTROL RESULTS SUMMARY
Blank Spike/Spike Duplicate

Work Order NO.: 4294

OC Sample NO.: SSTPH920915A & B Analytical Method: 418.1

Blank I.D.: MSTPH920915 Matrix: Soil

OC Batch NO.: S92QCB023TPH Unit: mg/Kg

Parameter	Date	Analyzed	BR	SA	BS	PR	BSD	PR	RPD
TPH	09/22/92	0	165	176	107	172	104	2	

BS-Blank Spike
BSD-Blank Spike Duplicate
SA-Spike Added
BR_Blank Result
NA-Not Applicable
NC-Not Calculated
ND-Not Detected

$$RPD = ((BS - BSD) / ((BS + BSD) / 2)) * 100$$

$$PR = ((BS \text{ OR } BSD - BR) / SA) * 100$$

ANALYST:

QUALITY CONTROL:

Stan J

INORGANICS DATA PACKAGE

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4294
Matrix: Solid

Client's ID: R1-A R1-V R1-V
-8.5'-10' -4.0'-4.5' -18'

Sample Date: 08/27/92 08/26/92 08/26/92

% Moisture:

Lab ID: 4294.01 4294.02 4292.03

Parameter	Results			Method	Normal Report	Units	Date Analyzed
					Limit		
Alkalinity	ND	ND	ND	SM 403(M)	50	mg/Kg CaCO ₃	09/10/92
Moisture	17.5	16.2	9.1	ASTM D2216	.1	% by wt	09/04/92
pH	5.2	4.9	5.4	EPA 9045	NA	pH Units	09/15/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable

ND- Not Detected

ANALYST: Don Gleator

GROUP LEADER: Willie Shelly

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4294
Matrix: Solid

Client's ID: Prep
Blank

Sample Date:
% Moisture:
Lab ID: Prep Blank

Parameter	Results	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	SM 403(M)	50	mg/Kg CaCO ₃	09/10/92
Moisture	NA	ASTM D2216	.1	% by wt	09/04/92
pH	NA	EPA 9045	NA	pH Units	09/15/92

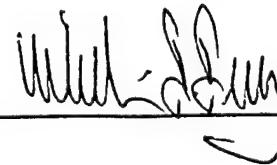
Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable

ND- Not Detected

ANALYST: Don Gleaton

GROUP LEADER:



ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS QC SUMMARY - LAB CONTROL SAMPLE

Work Order:	4294	% Moisture:	NA
Lab ID of LCS:		Matrix:	Solid
Alkalinity:	452.22 LCS	Units:	mg/Kg CaCO ₃

Parameter	Date Analyzed	LCS	Conc Result	Conc Added	% Rec	Advisory Limits		
	LCS	Result	Added	LCS		-- % Rec --	Low	High
Alkalinity	09/10/92	23000.00	23650.00		97		80	120

ANALYST: Don Gleaton Date 9/29/92 REVIEWER: MWB Date 9/11/92
File: M1QCLCSW

INORGANIC QC SUMMARY - MS and MSD

Work Order: 4294 % Moisture: NA

Lab ID Spk/Dup:	Alkalinity	Moisture	pH	Matrix:	Solid
QC Batch:	Blank Spk	4286.01	4294.01	Units:	mg/Kg CaCO ₃ (Alk)
	452.22	451.51	453.34		% by wt. (Mois)
					pH Units (pH)

Parameter	Date Analyzed	Results			RPD	RPD QC	-Conc Added-		Percent Recovered	
	MS/Dup	Unspiked Sample	MS/Sample	MSD/Dup			Limit	MS	MSD	MS
Alkalinity	09/10/92	0.00	23000.00	23000.00	0	20	23650.00	23650.00	97	97
Moisture	09/04/92		15.34	18.00	16	20				
pH	09/15/92		5.21	5.49	5	20				

* or N = Outside QC Limit:

ANALYST: Don Gleator Date 9/28/92 REVIEWER: MWB Date MWB
 File: M1QCHSWH

QC Limits for % Rec: 75 - 125

METALS DATA PACKAGE

METALS CASE NARRATIVE
WORK ORDER NO.4294
SOILS

The concentration of iron in sample MPA-18 was greater than four times the spike added to the MS and MSD samples. The LCS and duplicate LCS results for iron were checked, and the laboratory was found to be in control. All iron results in this batch are therefore reported unqualified based on matrix spike recovery.

The serial dilution sample result for iron did not agree with the undiluted result within 10%, and the diluted sample result was greater than ten times the iron MDL. All iron results in this batch are therefore flagged with "E".

Client ID's were abridged by the laboratory to facilitate computer entry of analytical data. The following should be used as a reference:

<u>CLIENT ID</u>	<u>ABRIDGED ID</u>
R1-A-8.5'-10'	A-8.5'
R1-V-4.0'-4.5'	V-4.0'
R1-V-18'	V-18'

Engineering Science - Berkeley Laboratory
Inorganics Report

CLIENT SAMPLE ID

INORGANIC ANALYSES DATA SHEET

A-8,5'

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE

Lab Code: ESBL **Case No.:** 4294S **SAS No.:** _____ **SDG No.:** A-3 _____

Matrix (soil/water): SOIL Lab Sample ID: 4294.01

Level (low/med) : LOW Date Sampled : 08/27/92

Solids: 82.5

Concentration Units ($\mu\text{g/L}$ or mg/kg dry weight): MG/KG

Comments:

Engineering Science - Berkeley Laboratory Inorganics Report

CLIENT SAMPLE ID

INORGANIC ANALYSES DATA SHEET

V-4.0'

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE _____

Lab Code: ESBL Case No.: 4294S SAS No.: _____ SDG No.: A-3_____

Matrix (soil/water): SOIL Lab Sample ID: 4294.02

Level (low/med): LOW Date Sampled : 08/26/92

% Solids: 83.8

Concentration Units (ug/L or mg/kg dry weight): MG/KG

Comments:

Engineering Science - Berkeley Laboratory
Inorganics Report

CLIENT SAMPLE ID

INORGANIC ANALYSES DATA SHEET

V-18'

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE

Lab Code: ESBL **Case No.:** 4294S **SAS No.:** _____ **SDG No.:** A-3 _____

Matrix (soil/water): SOIL Lab Sample ID: 4294.03

Level (low/med) : LOW Date Sampled : 08/26/92

Solids: 90.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

Comments:

Engineering Science Berkeley Laboratory
Inorganics Report

CLIENT SAMPLE ID

INORGANIC ANALYSES DATA SHEET

PBLANK

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE

Lab Code: ESBL Case No.: 4294S SAS No.: SDG No.: A-3

Matrix (soil/water): SOIL_ Lab Sample ID: PREP BLANK

Level (low/med): LOW Date Sampled : 09/16/92

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

Comments:

FORM I - IN

3 / 90

Engineering Science - Berkeley Laboratory Inorganics Report

CLIENT SAMPLE ID

SPIKE SAMPLE RECOVERY

Lab Name: E S BERKELEY LABORATORY

Contract: AFCEE

MPA-18S1

Lab Code: ESBL

Case No.: 4294S

SAS No.: _____

SDG No.: A-3

Matrix (soil/water): SOIL

Level (low/med): LOW

Solids for Sample: 94.7

Concentration Units (ug/L or mg/kg dry weight): MG/KG

Comments:

SPIKE SAMPLE RECOVERY

MPA-18S2

Lab Name: E S BERKELEY LABORATORY

Contract: AFCEE _____

Lab Code: ESBL

Case No.: 4294S

SAS No.:

SDG No.: A-3

Matrix (soil/water): SOIL

Level (low/med): LOW

% Solids for Sample: 94.7

Concentration Units ($\mu\text{g/L}$ or mg/kg dry weight): MG/KG

Comments:

Engineering Science - Berkeley Laboratory Inorganics Report

CLIENT SAMPLE ID

MATRIX SPIKE DUPLICATE

MPA-18SD

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE

Lab Code: ESBL Case No.: 4294S SAS No.: _____ SDG No.: A-3_____

Matrix (soil/water): SOIL Level (low/med): LOW

~~1~~ Solids for Sample: 94.7 % Solids for Duplicate: 94.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

Engineering Science - Berkeley Laboratory Inorganics Report

BLANK SPIKE SAMPLE

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE _____
Lab Code: ESBL__ Case No.: 4294S SAS No.: _____ SDG No.: A-3 _____
Solid LCS Source: ESBL-LCSS_____
Aqueous LCS Source: _____

Engineering Science - Berkeley Laboratory
Inorganics Report

BLANK SPIKE SAMPLE

Lab Name: E S BERKELEY LABORATORY

Contract: AFCEE _____

Lab Code: ESBL Case No.: 4294S

SAS No.: _____ SDG No.: A-3 _____

Solid LCS Source: ESBL-LCSS

Aqueous LCS Source: _____

Engineering Science - Berkeley Laboratory
Inorganics Report

CLIENT SAMPLE ID

BLANK SPIKE DUPLICATE

LCSSD

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE _____

Lab Code: ESBL Case No.: 4294S SAS No.: _____ SDG No.: A-3_____

Matrix (soil/water): SOIL_ Level (low/med): LOW

% Solids for Sample: 100.0 % Solids for Duplicate: 100.0

Concentration Units (ug/L or mg/kg as received): MG/KG

Engineering Science - Berkeley Laboratory
Inorganic Report

EPA SAMPLE NO.

ICP SERIAL DILUTION

MPA-18L

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE _____

Lab Code: ESB Case No.: 4294S SAS No.: SDG No.: A-3

Natrix (soil/water): SOIL _____ Level (low/med): LOW _____

Concentration Units: ug/L

Method Detection Limits (Annually)

Lab Name: E S BERKELEY LABORATORY Contract: AFCEE

Lab Code: ESB_L Case No.: 4294S SAS No.: SDG No.: A-3

ICP ID Number: TJA 61 M Date: 09/01/92

Flame AA ID Number : _____ Matrix: SOIL_

Furnace AA ID Number : _____ (ug/L in 1.00g to 100ml digestate)

Comments:

Engineering Science - Berkeley Laboratory
Inorganics Report

PREPARATION LOG

Lab Name: E_S_BERKELEY LABORATORY

Contract: AFCEE _____

Lab Code: ESBL

Case No.: 4294S

SAS No.: _____

SDG No.: A-3 _____

Method: P

FORM XIII - IN

ILMO2.1

ANALYSIS RUN LOG

Lab Name: E_S_BERKELEY_LABORATORY_

Contract: AFCEE_____

Lab Code: ESBL_ Case No.: 4294S_

SAS No.: _____ SDG No.: A-3_____

Instrument ID Number: TJA 61 M_

Method: P_

Start Date: 09/17/92

End Date: 09/17/92

EPA Sample No.	D/F	Time	% R	Analytes											
				F	E	G	H	I	J	K	L	M	N	O	P
STD1	1.00	1423		X	-	-	-	-	-	-	-	-	-	-	-
STD2	1.00	1427		X	-	-	-	-	-	-	-	-	-	-	-
STD3	1.00	1432		X	-	-	-	-	-	-	-	-	-	-	-
STD4	1.00	1437		X	-	-	-	-	-	-	-	-	-	-	-
ICV	1.00	1441		X	-	-	-	-	-	-	-	-	-	-	-
ICB	1.00	1446		X	-	-	-	-	-	-	-	-	-	-	-
ICSA	1.00	1451		X	-	-	-	-	-	-	-	-	-	-	-
ICSAB	1.00	1455		X	-	-	-	-	-	-	-	-	-	-	-
CRI	1.00	1500		-	-	-	-	-	-	-	-	-	-	-	-
PBLANK	1.00	1504		X	-	-	-	-	-	-	-	-	-	-	-
ZZZZZZ	1.00	1509		-	-	-	-	-	-	-	-	-	-	-	-
LCSS	1.00	1514		X	-	-	-	-	-	-	-	-	-	-	-
LCSSD	1.00	1518		X	-	-	-	-	-	-	-	-	-	-	-
A-8.5'	1.00	1523		X	-	-	-	-	-	-	-	-	-	-	-
V-4.0'	1.00	1527		X	-	-	-	-	-	-	-	-	-	-	-
V-18'	1.00	1532		X	-	-	-	-	-	-	-	-	-	-	-
CCV	1.00	1537		X	-	-	-	-	-	-	-	-	-	-	-
CCB	1.00	1541		X	-	-	-	-	-	-	-	-	-	-	-
V-7'3"	1.00	1546		X	-	-	-	-	-	-	-	-	-	-	-
A-5	1.00	1551		X	-	-	-	-	-	-	-	-	-	-	-
A-3	1.00	1555		X	-	-	-	-	-	-	-	-	-	-	-
VW-8	1.00	1600		X	-	-	-	-	-	-	-	-	-	-	-
MPA-07	1.00	1604		X	-	-	-	-	-	-	-	-	-	-	-
MPA-18	1.00	1609		X	-	-	-	-	-	-	-	-	-	-	-
MPA-18S1	1.00	1614		X	-	-	-	-	-	-	-	-	-	-	-
MPA-18S2	1.00	1618		X	-	-	-	-	-	-	-	-	-	-	-
MPA-18L	1.00	1623		X	-	-	-	-	-	-	-	-	-	-	-
CCV	1.00	1627		X	-	-	-	-	-	-	-	-	-	-	-
CCB	1.00	1632		X	-	-	-	-	-	-	-	-	-	-	-
MPB-18	1.00	1637		X	-	-	-	-	-	-	-	-	-	-	-
MPB-06	1.00	1641		X	-	-	-	-	-	-	-	-	-	-	-
MPC-06	1.00	1646		X	-	-	-	-	-	-	-	-	-	-	-

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E S BERKELEY LABORATORY

Contract: AFCEE

Lab Code: ESBL Case No.: 4294S

SAS No.: _____ SDG No.: A-3 _____

Instrument ID Number: TJA 61 M

Method: P

Cart Date: 09/17/92

End Date: 09/17/92

**TOTAL KJELDAHL NITROGEN
TOTAL PHOSPHATE
SOIL CLASSIFICATION
DATA PACKAGE**



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

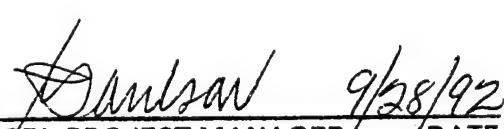
Client Project ID: W.O. #4294
Sample Descript: Soil
Analysis for: Total Phosphorous
First Sample #: 209-0160

Sampled: 8/26-27/92
Received: Sep 2, 1992
Analyzed: Sep 16, 1992
Reported: Sep 21, 1992

LABORATORY ANALYSIS FOR: Total Phosphorous

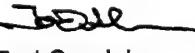
Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
209-0160	R1-A-8.5'-10'	10	79
209-0161	R1-V-4.0'-4.5'	10	110
209-0162	R1-V-18'	10	64
-	Method Blank	10	N.D.

THIS REPORT HAS BEEN
APPROVED AND REVIEWED BY


Tod Granicher 9/28/92
ESBL PROJECT MANAGER DATE

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL


Tod Granicher
Project Manager

Please Note:

Analysis results reported on a dry-weight basis.

2090160.ENG <4>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil
Analysis for: Total Kjeldahl Nitrogen
First Sample #: 209-0160

Sampled: 8/26-27/92
Received: Sep 2, 1992
Analyzed: Sep 3, 1992
Reported: Sep 21, 1992

LABORATORY ANALYSIS FOR: Total Kjeldahl Nitrogen

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
209-0160	R1-A-8.5'-10'	20	68
209-0161	R1-V-4.0'-4.5'	20	110
209-0162	R1-V-18'	20	92
	Method Blank	20	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL


Tod Granicher
Project Manager

Please Note:

Analysis results reported on a dry-weight basis.



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294

QC Sample Group: 209-0160-62

Reported: Sep 21, 1992

QUALITY CONTROL DATA REPORT

ANALYTE	Total Kjeldahl Nitrogen	Total Phosphorous
---------	----------------------------	-------------------

Method: EPA351.4 EPA365.3
Analyst: G. Kern K. Follett
Reporting Units: mg/kg mg/kg
Date Analyzed: Sep 3, 1992 Jul 16, 1992
QC Sample #: 209-0162 209-0841

Sample Conc.: 84 40

Spike Conc.
Added: 4000 100

Conc. Matrix
Spike: 4600 120

Matrix Spike
% Recovery: 113 80

Conc. Matrix
Spike Dup.: 4600 130

Matrix Spike
Duplicate
% Recovery: 113 90

Relative
% Difference: 0.0 8.0

SEQUOIA ANALYTICAL

Todd
Tod Granicher
Project Manager

% Recovery:	$\frac{\text{Conc. of M.S.} - \text{Conc. of Sample}}{\text{Spike Conc. Added}}$	x 100
Relative % Difference:	$\frac{\text{Conc. of M.S.} - \text{Conc. of M.S.D.}}{(\text{Conc. of M.S.} + \text{Conc. of M.S.D.}) / 2}$	x 100



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil, R1-A-8.5'-10'
Method of Analysis: ASTM D422-63
Lab Number: 209-0160

Sampled: Aug 27, 1992
Received: Sep 2, 1992
Analyzed: Sep 9, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
- (B) WEIGHT RETAINED IN NO. 10 SIEVE:
- (C) % PASSING NO. 10 SIEVE:

229.98g
0.75g
99.67

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	0.0	0.0	0.0	100
No. 10	0.75g	0.33	0.33	99.67
PAN	0.0			
TOTAL	0.75g			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	22	18	13.3	0.035
5	21	20	16	13.7	0.022
10	21	19	15	13.8	0.016
15	21	18	14	14.0	0.013
25	21	18	14	14.0	0.010
40	21	18	14	14.0	0.0080
60	21	17	13	14.2	0.0067
90	21	17	13	14.2	0.0054
120	21	17	13	14.2	0.0046
1440	21	16	12	14.3	0.0013

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
SPECIFIC GRAVITY (ASSUMED):
DISPERSING AGENT CORRECTION FACTOR (E):
MENISCUS CORRECTION FACTOR (F):
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.988
2.65
3
1
0.01348

FORMULAS:
 $R = H - E - F$
 $S = K [\text{SQRT} (L/T)]$
 $P = (R/W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

2090160.ENG <1>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil, R1-V-4.0'-4.5'
Method of Analysis: ASTM D422-63
Lab Number: 209-0161

Sampled: Aug 26, 1992
Received: Sep 2, 1992
Analyzed: Sep 9, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
 - (B) WEIGHT RETAINED IN NO. 10 SIEVE:
 - (C) % PASSING NO. 10 SIEVE:

155.43g
0.50g
99.68

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	0.0	0.0	0.0	100
No. 10	0.50	0.32	0.32	99.68
PAN	0.0			
TOTAL	0.50			

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	29	25	12.2	0.033
5	21	28	25	12.4	0.021
10	21	27	23	12.5	0.015
15	21	27	23	12.5	0.012
25	21	27	23	12.5	0.0095
40	21	26	22	12.7	0.0076
60	21	26	22	12.7	0.0062
90	21	25	21	12.9	0.0051
120	21	24	20	13.0	0.0044
1440	21	24	20	13.0	0.0013

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
SPECIFIC GRAVITY (ASSUMED):
DISPERSING AGENT CORRECTION FACTOR (E):
MENISCUS CORRECTION FACTOR (F):
TEMP /SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.996
2.65
3
1
0.01348

FORMULAS:

$$R = H - E - F$$

$$S = K [\text{SQRT} (L / T)]$$

$$P = (R / W) 100$$

$$W = (J \cdot 100) / C$$

$$J = D \cdot G$$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descrip: Soil, R1-V-18'
Method of Analysis: ASTM D422-63
Lab Number: 209-0162

Sampled: Aug 26, 1992
Received: Sep 2, 1992
Analyzed: Sep 9, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
(B) WEIGHT RETAINED IN NO. 10 SIEVE:
(C) % PASSING NO. 10 SIEVE:

185.38g
38.93g
79.00

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT		CUMULATIVE % RETAINED	CUMULATIVE % PASSING
	RETAINED, g	% RETAINED		
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	5.49	2.96	2.96	97.04
No. 10	33.44	18.04	21.00	79.00
PAN	0.0			
TOTAL	38.93			

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	22	18	13.3	0.035
5	21	20	16	13.7	0.022
10	21	19	15	13.8	0.016
15	21	19	15	13.8	0.013
25	21	19	15	13.8	0.010
40	21	18	14	14.0	0.0080
60	21	18	14	14.0	0.0065
90	21	18	14	14.0	0.0053
120	21	17	13	14.2	0.0046
1440	21	17	13	14.2	0.0013

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
SPECIFIC GRAVITY (ASSUMED):
DISPERSING AGENT CORRECTION FACTOR (E):
MENISCUS CORRECTION FACTOR (F):
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.991
2.65
3
1
0.01348

FORMULAS:
 $R = H - E - F$
 $S = K [\sqrt{L/T}]$
 $P = (R/W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

SEQUOIA ANALYTICAL

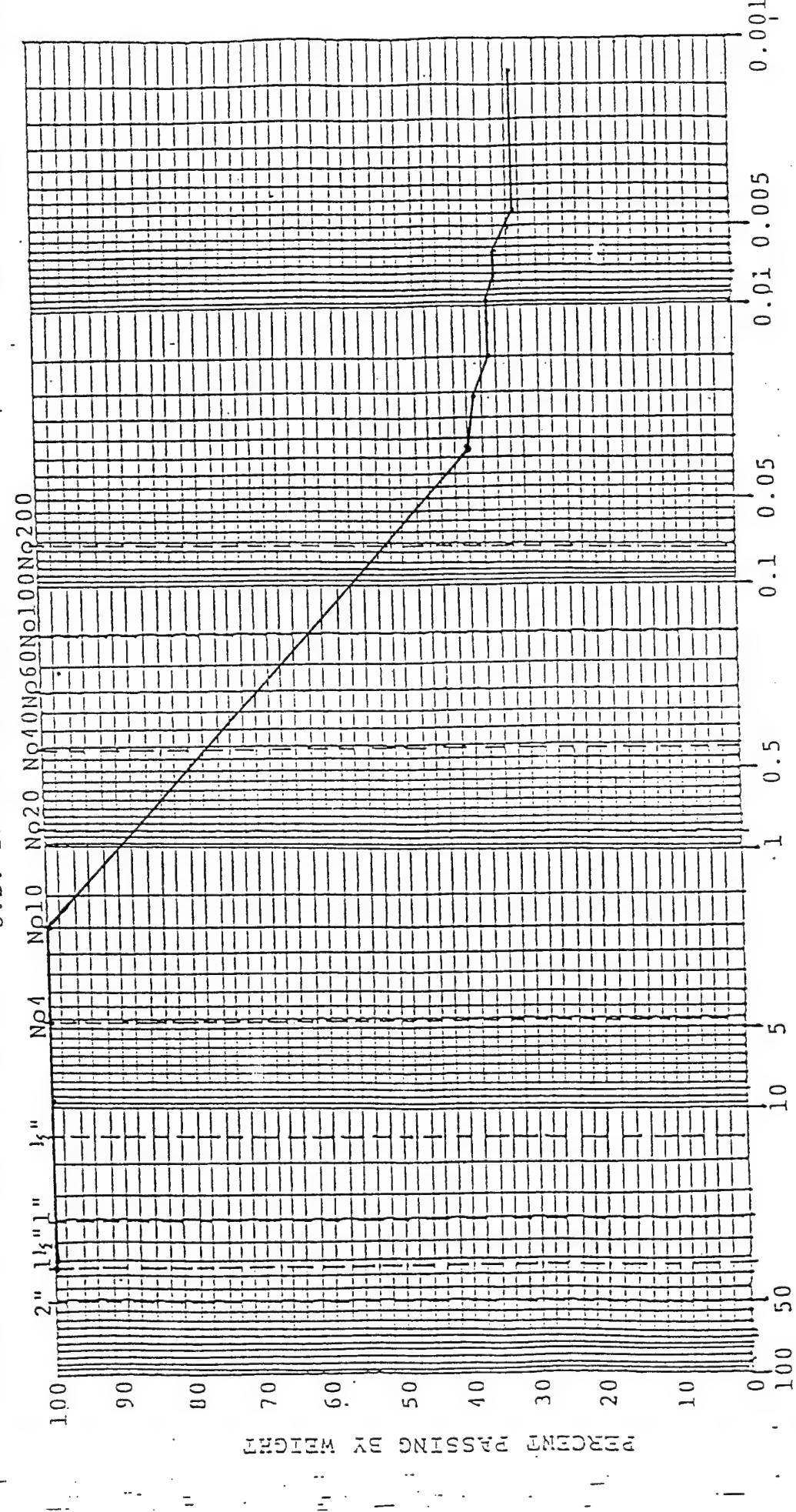
Tod Granicher
Tod Granicher
Project Manager

2090160.ENG <3>

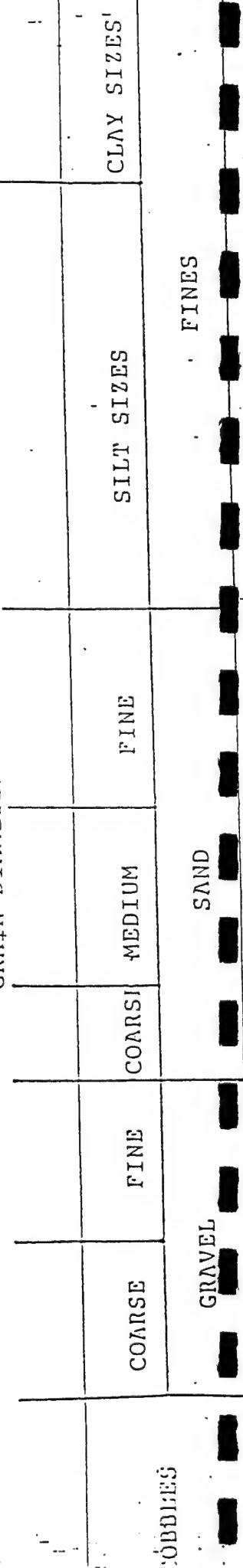
SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 209-0161

GRAVEL	0%
SAND	49%
SILT	20%
CLAY	31%



GRAIN DIAMETER IN MILLIMETERS



SAMPLE DESCRIPTION: Engineering Science, Inc.

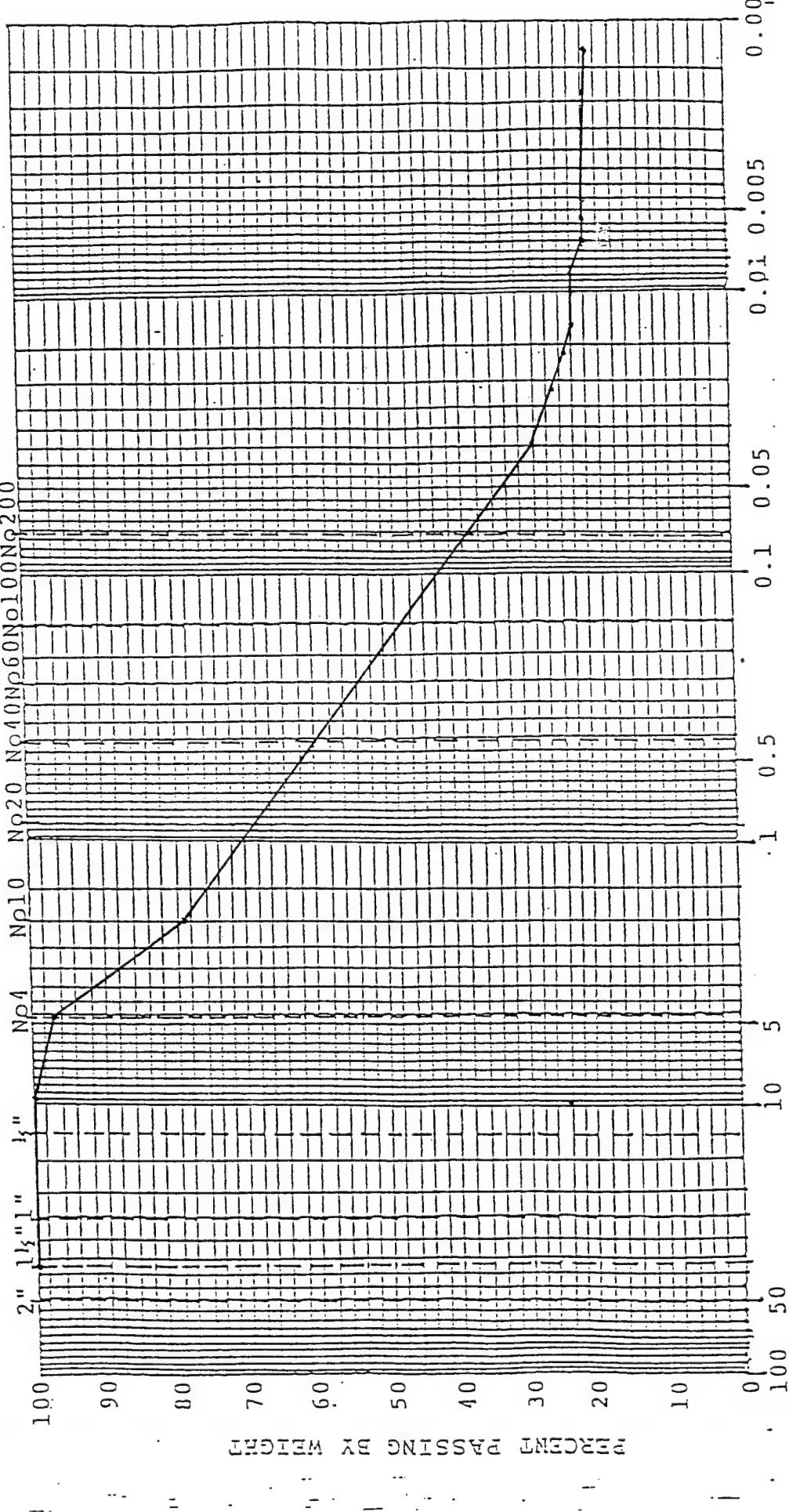
LABORATORY NUMBER: 209-0162

SAND 40%

SILT 37%

CLAY 20%

U.S. STANDARD SIEVE SIZES



GRAIN DIAMETER IN MILLIMETERS

CLAY SIZES	SILT SIZES	FINE	COARSE		
			FINE	MEDIUM	COARSE
SAND					
GRAVEL					
OBSES					

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO.	PROJECT NAME/LOCATION	PRESERVATIVES REQUIRED										SHIP TO:
		ANALYSES REQUIRED										
FIELD CONTACT:												
SAMPLERS NAMES & SIGNATURES <i>Charles J. Estellito M. De Los Trinos</i>												
TOTAL PHOSPHATE/TIN Sieve & liquid treatment added for pH												
DATE	TIME	FIELD SAMPLE IDENTIFIER										REMARKS
27/AUG/92	0930	R1-A-8.5'-10' (4294.018)										Quartz TAT
26/AUG/92	1400	R1-V-4.5'-4.5' (4294.028)										Report to: Tom Dauben ES
26/AUG/92	1515	R1-V-18' (4294.038)										Report results to: dry soil basis. Report MSD & Phosphate results
												Total phosph. by 365.3 TKN by 357.2
												DATE: 9/12/92 TIME: 11:25 AM
												DATE: 9/12/92 TIME: 11:25 AM
FIELD CUSTODY RELINQUISHED BY: <i>J. J. Miller</i>		ON RECEIPT: CUSTODY SEALS? _____										SHIPPED VIA: AIRBILL # <i>1000</i>
RECEIVED FOR LABORATORY BY: <i>Charles J. Estellito M. De Los Trinos</i>												RECEIVED DATE: 9/12/92

APPENDIX B

SITE UST 173 SOIL GAS PERMEABILITY DATA

TABLE B-1. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT R1-MPA

Time (min)	Pressure (psi) at Depth (feet)			Time (min)	Pressure (psi) at Depth (feet)		
	6'10"	14'3"	21'10"		6'10"	14'3"	21'10"
0	0	0.01	0.01	20	0	0.22	0.25
1	0	0.14	0.23	23	0	0.215	0.25
2	0	0.145	0.235	26	0	0.22	0.25
3	0	0.155	0.235	29	0	0.215	0.25
4	0	0.165	0.235	32	0	0.22	0.25
5	0.005	0.170	0.24	37	0	0.22	0.25
6	0.005	0.180	0.24	42	0	0.205	0.25
7	0.005	0.185	0.24	47	0	0.235	0.25
8	0	0.19	0.239	57	0	0.235	0.25
9	0	0.185	0.245	67	0	0.25	0.30
10	0	0.185	0.245	77	0	0.25	0.35
12	0	0.190	0.25	87	0	0.25	0.35
14	0	0.190	0.25	107	0	0.25	0.35
16	0	0.195	0.25	127	0	0.25	0.35
18	0	0.20	0.25	147	0	0.25	0.35

TABLE B-2. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT R1-MPB

Time (min)	Pressure (psi) at Depth (feet)			Time (min)	Pressure (psi) at Depth (feet)		
	8'	15'	23'		8'	15'	23'
0	<0	<0	0.02	23	0.01	0.19	0.20
1	0.005	0.1	0.12	26	0.01	0.19	0.20
2	0.01	0.12	0.135	29	0.01	0.185	0.19
3	0.015	0.13	0.14	32	0.005	0.175	0.19
4	0.025	0.13	0.145	38	0.005	0.18	0.195
5	0.02	0.135	0.155	48	0.03	0.195	0.21
6	0.025	0.14	0.155	53	0.025	0.20	0.22
7	0.025	0.14	0.155	58	0.02	0.2	0.22
8	0.025	0.145	0.16	68	0.03	0.21	0.235
9	0.25	0.14	0.16	78	0.14	0.25	0.30
10	0.025	0.14	0.16	88	0.10	0.25	0.30
12	0.02	0.16	0.17	98	0.04	0.25	0.27
14	0.015	0.16	0.175	108	<0	0.24	0.25
16	0.01	0.165	0.185	118	<0	0.22	0.30
18	0.015	0.17	0.19	138	<0	0.22	0.30
20	0.01	0.18	0.20	148	<0	0.21	0.30

TABLE B-3. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT R1-MPC

Time (min)	Pressure (psi) at Depth (feet)			Time (min)	Pressure (psi) at Depth (feet)		
	8'	15'	23'		8'	15'	23'
0	0	0.02	0.02	26	0.013	0.165	0.165
1	0	0.095	0.10	29	0.015	0.165	0.165
2	0	0.11	0.11	32	0.013	0.173	0.170
3	0.005	0.115	0.119	35	0.013	0.173	0.175
4	0.007	0.12	0.12	40	0.013	0.167	0.163
5	0.01	0.135	0.135	45	0.015	0.185	0.185
6	0.01	0.145	0.145	50	0.015	0.193	0.193
7	0.01	0.137	0.140	55	0.010	0.193	0.193
8	0.01	0.139	0.140	60	0.017	0.203	0.196
9	0.01	0.140	0.140	70	0.020	0.200	0.196
10	0.01	0.147	0.150	80	0.020	0.220	0.220
12	0.01	0.155	0.155	90	0.020	0.227	0.227
14	0.01	0.155	0.157	100	0.017	0.225	0.222
16	0.013	0.163	0.165	110	0.015	0.222	0.222
18	0.013	0.165	0.167	120	0.025	0.245	0.243
20	0.015	0.180	0.183	140	0.02	0.220	0.220
23	0.013	0.183	0.183				

APPENDIX C

SITE UST 173 IN SITU RESPIRATION TEST DATA

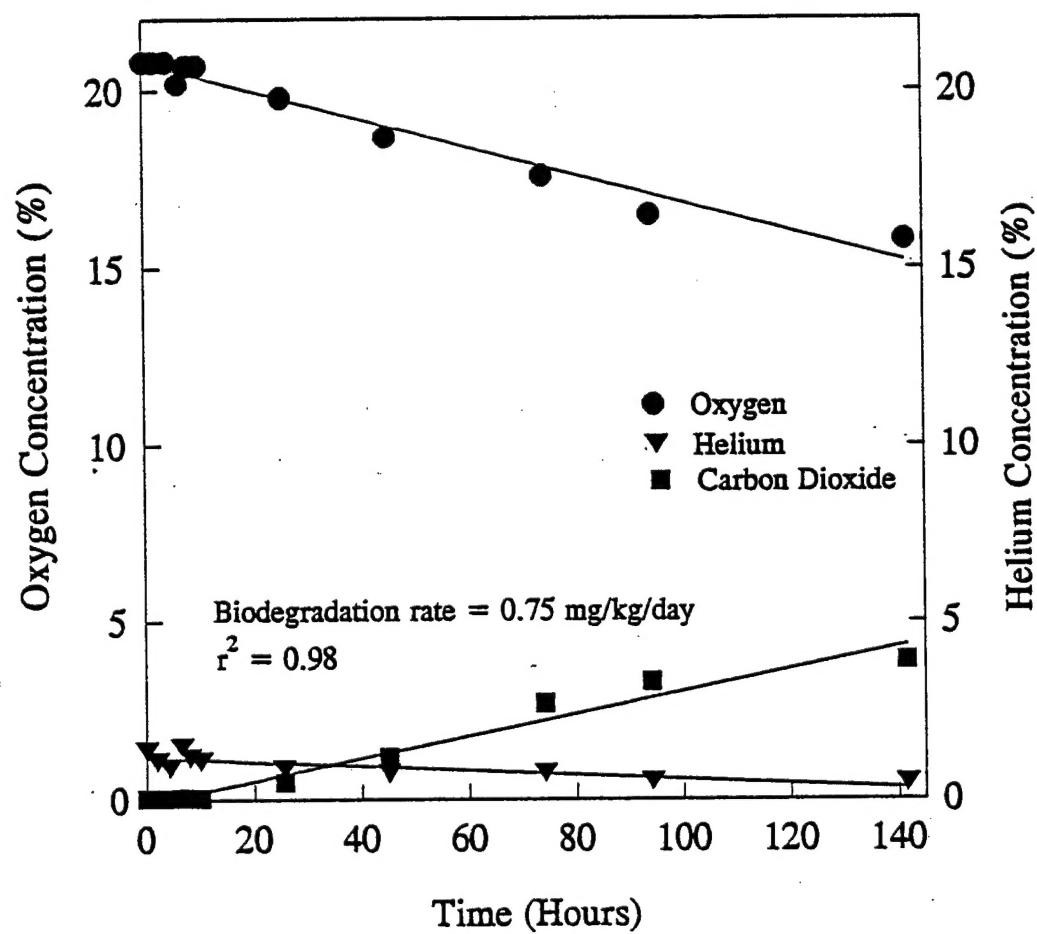


Figure C-1. Oxygen Utilization During In Situ Respiration Test at Monitoring Point R1-MPA-14'3"

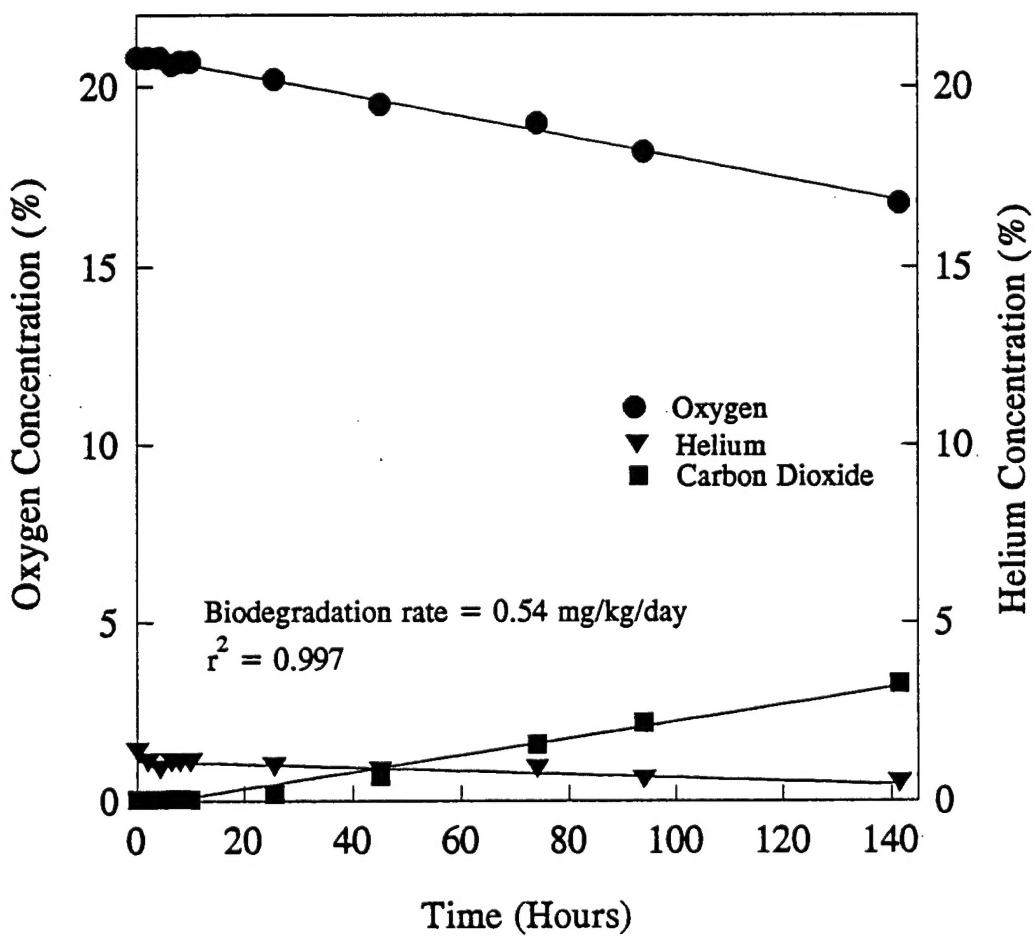


Figure C-2. Oxygen Utilization During In Situ Respiration Test at Monitoring Point R1-MPA-21'10"

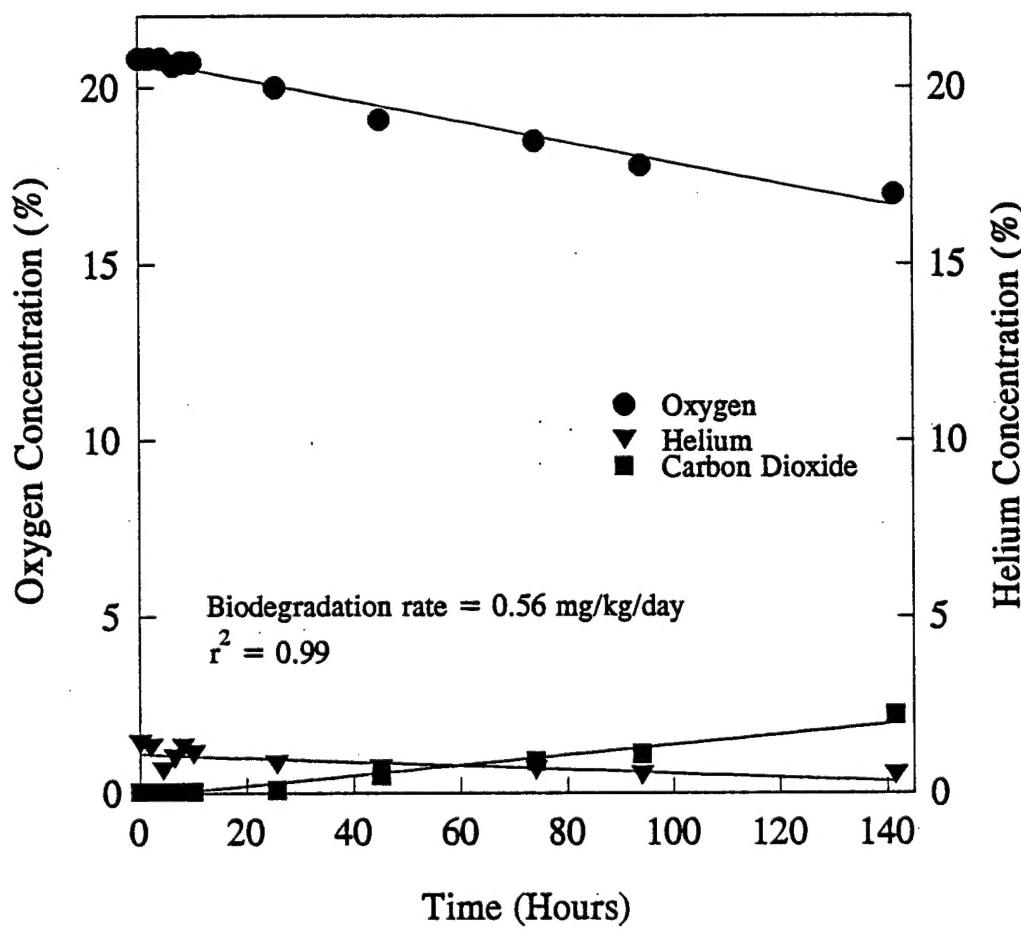


Figure C-3. Oxygen Utilization During In Situ Respiration Test at Monitoring Point R1-MPA-15'

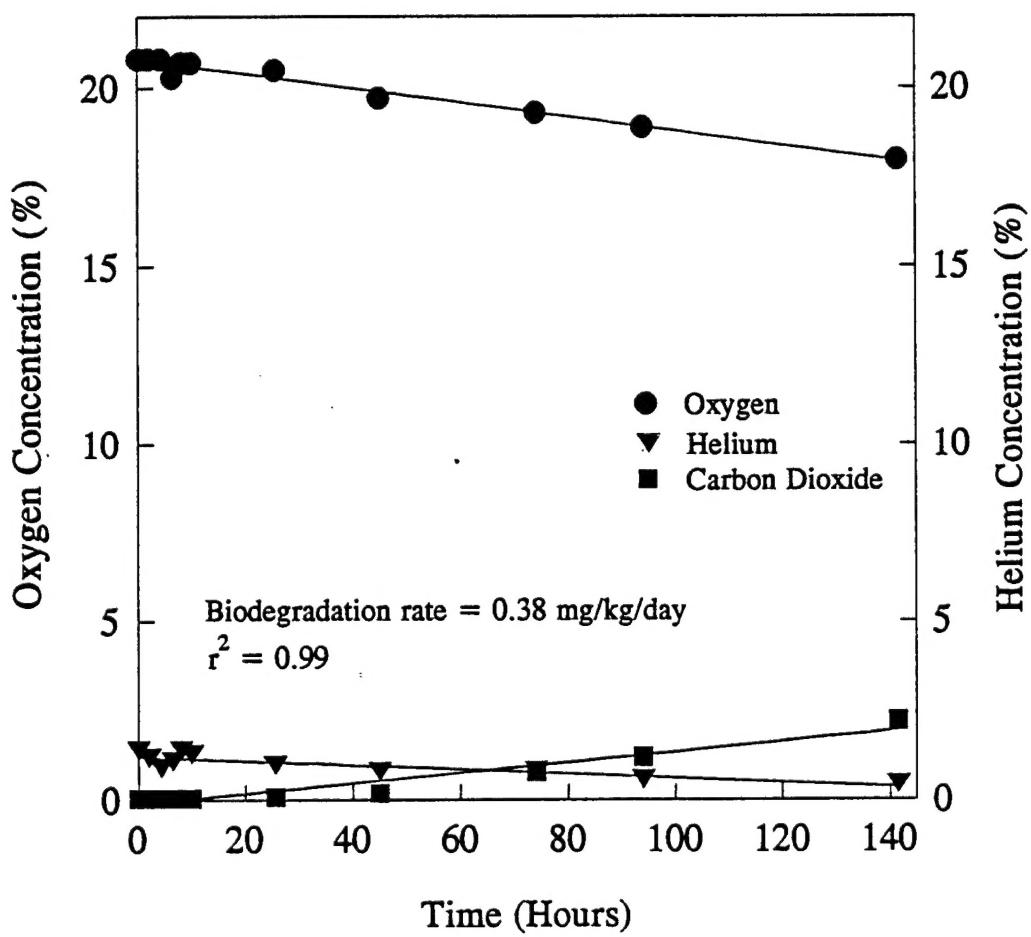


Figure C-4. Oxygen Utilization During In Situ Respiration Test at Monitoring Point R1-MPA-23'